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ANNUAL DIFFERENCES AND SPECIES TURNOVER IN PEAT BOG SPIDER COMMUNITIES

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ABSTRACT. The yearly differences between material collected over two years by means of pitfall traps in three peat bogs in Lithuania and one in Finland were analyzed. Single year collections formed 58.8–87.9% of all the species collected over the two year period. No turnover occurred in the abundant species (> 1% of all specimens in one year sample) if traps were not relocated. The rates of the turnover can vary considerably in various dominance groups and show different trends at different sites. Marked annual differences in abundance were recorded even among some typically abundant peat bog species like *Pardosa sphagnicola*, *Drassyllus pusillus*, *Scotina palliardi*, *Agyneta cauta*, *Arctosa alpigena*, *Bathyphantes gracilis*, *Antistea elegans*, and *Drassodes pubescens*. Only a few species typical of other habitats were found to be permanently abundant in peat bogs. Five species recorded during the investigation are new to the spider fauna of Lithuania.

Keywords: Araneae, annual differences, communities, peat bogs, Finland, Lithuania

Evaluation of biodiversity in various invertebrate groups and habitats is a problem currently under intensive investigation. New research methods on this subject have been developed, and their effectiveness has been discussed (Duelli et al. 1990; Coddington et al. 1996; Duelli 1997; Riecken 1999, 2000). Despite known weaknesses of pitfall trapping, it is still an important sampling method used in these investigations as well as for spider research in peat bogs (Koponen 1979, 1994; Platen 1989; Schikora 1994, 1997; Relys & Dapkus 2002). Material collected during a single year is often used for inventories and bioindicator research, due to limited time and resources available for investigations. Riecken (2000) found that single year collections by pitfalls formed only 56.8%–84.0% of all species collected during a two year investigation from 20 different habitats (peat bogs not included) in Germany. Such a large number of appearing and disappearing species in a community (turnover), as well as fluctuations in relative abundance of permanently occurring species, cause annual differences in the community structure. This could result in misleading interpretations if the analyses are based on a single year. Few studies have directly addressed year-to-year differences in spider communities (Norris 1999). Two or more year's data on peat bog spiders have usually been combined in analyses (Schikora 1994; Kuprijanovitz et al. 1998). The aim of this article is to examine year-to-year differences in peat bog spider communities. We also try to identify and discuss the most stable species groups, suitable for use as indicators in peat bogs.

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METHODS

Study sites.—This research was carried out in three peat bogs (L-A, L-B, L-C) in Eastern Lithuania: Balosa (L-A, 54°53'N, 25°48'E), Kertusas (L-B, 55°08'N, 24°54'E), Laukenai (L-C, 55°11'N, 25°03'E), and in one peat bog in Southern Finland: Kareva (F, 60°32'N, 22°09'E). The peat bogs in Lithuania were pine bogs (*Pinus silvestris–Ledum palustre–*

Sphagnum) overgrown with pine trees of various age and density. The bog in Finland was an open peat bog (*Eriophorum vaginatum–Sphagnum*).

Data collection.—All collecting was done with pitfall traps. The data in Lithuania were collected in 1999 and 2000. Data from Finland were collected in 1964 and 1966 and used to provide information about the differences between the samples separated by one year (1965). Six plastic jars (volume 300 ml, depth 10 cm, diameter 7 cm) filled with 100–120 ml of 4% formaldehyde solution mixed with drops of detergent were used at each locality in Lithuania. In Lithuania the traps were operated from April–October in 1999 and 2000. The traps were emptied every 3 weeks. In Finland 20 traps with ethylene glycol and detergent were set 1.5–2 m apart and emptied in 2 week intervals, June–August 1964 and 1966. The traps in one peat bog in Lithuania (L-C) were moved in 2000 about 90 m from the site investigated in 1999. There were no marked differences in vegetation between the sites. The abbreviations of samples taken from Lithuania in 1999 are L-A99, L-B99, and L-C99, and samples taken in 2000 are L-A00, L-B00, and L-C00. F64 and F66 refer to the years of studies performed in Finland in 1964 and 1966.

Data analysis.—Turnover index: The rates of turnover in a community between time periods are of a qualitative nature and can be described as the index of turnover. According to MacArthur & Wilson (1967), turnover estimates the number of local colonizations and extinctions related to the number of species in the community. Originally this index was developed for islands; it can also be used for isolated terrestrial units often called "terrestrial islands". Peat bogs, especially small ones surrounded by other habitat types and bearing unique or stenotopic elements of flora and fauna, often represent typical cases of such "islands". The use of the turnover index for spider communities was demonstrated by Norris (1999). The turnover index (*Tn*) was calculated by dividing the sum of appearing and disappearing species over two years by the sum of species found in each of the years (Russell et al. 1995; Norris 1999). The index ranges from 0–1. *Percent similarity coefficient*: We use this abundance-based coefficient (*PSc*) to describe changes in species abundance in whole sets of species and in various dominance (abundance) groups in communities between the years. The coefficient reflects similarity of proportional representation of the species in the community and is not affected by the sample size. Higher coefficient values indicate higher similarity and show lower differences and changes in species abundance. The formula for calculating *PSc* can be obtained from Wolda (1981). Like some other abundance-based measures, the percent similarity coefficient, being of quantitative nature, is also affected by turnover, especially if it occurs in abundant species.

Nomenclature used is according to Platnick (1997) and the material from Lithuania and Finland is deposited in the Zoological Museum of the Department of Zoology, Vilnius University and in the Zoological Museum, University of Turku, respectively.

RESULTS AND DISCUSSION

General overview of the data.—The material analyzed comprised 8245 adult spider specimens representing 146 species. Of these, 43 species were singletons, and another 32 were represented by three or fewer specimens. The differences in species and individual numbers were obvious in all communities for the compared years (Table 1). In L-B and L-C, higher species diversity was registered in the year with fewer individuals. More than 50% of all species found each year were represented by three or fewer individuals. An increase in the total number of species due to newly appearing species was found in all the communities during the second year of the study. The percentage of species found during a single study year (58.8–87.9% of the total two-year collection) was very close to that (average 74.5%) found in 20 different habitats by Riecken (2000), using the same collecting methods. On average, 75.2% of species were found by us during a single year in the peat bogs. Only a few species were consistently found in low numbers. Even some of small-sized species of Linyphiidae or Theridiidae (*Agyneta* spp., *Bathyphantes* spp., *Bolyphantes* spp., *Maro* spp., *Theonoe minutissima* (O.P.-Cambridge 1879), etc.) were found in high numbers in some years. This shows that the data obtained by pitfall trapping could also provide valuable information about the relative abundance of such species. Five species

Table 1.—Data on the spider material collected during two years from four peat bogs in Lithuania and Finland. L-A = Balosa, L-B = Kertusas, L-C = Laukenai, = Kareva. Samples taken in 1999 are L-A99, L-B99, L-C99 and in 2000: L-A00, L-B00, and L-C00. F64 and F66 refer to the years of studies performed in Finland in 1964 and 1966.

	L-A99	L-A00	L-B99	L-B00	L-C99	L-C00	F-64	F-66
No. individuals	765	752	1202	907	1147	852	1455	1165
No. species/year	52	48	47	62	40	51	73	55
No. species/total (two years)		60		74		68		83
Appeared/Disappeared in second year		8/12		27/12		28/17		9/26
% of species of two years in one year	86.6	80	63.5	83.8	58.8	75	87.9	66.3
No. species < 3 individuals	33	25	24	37	21	30	42	28
% species < 3 individuals	63.5	52.1	51.1	59.7	52.5	58.8	57.5	50.9
No. species > 3 individuals	19	23	23	25	19	21	31	27
No. species (> 1% of indiv.) in one year	9	14	13	15	12	13	15	11
% species (>1% of indiv.) in one year	17.3	29.2	27.7	24.2	30.0	25.5	20.5	20.0

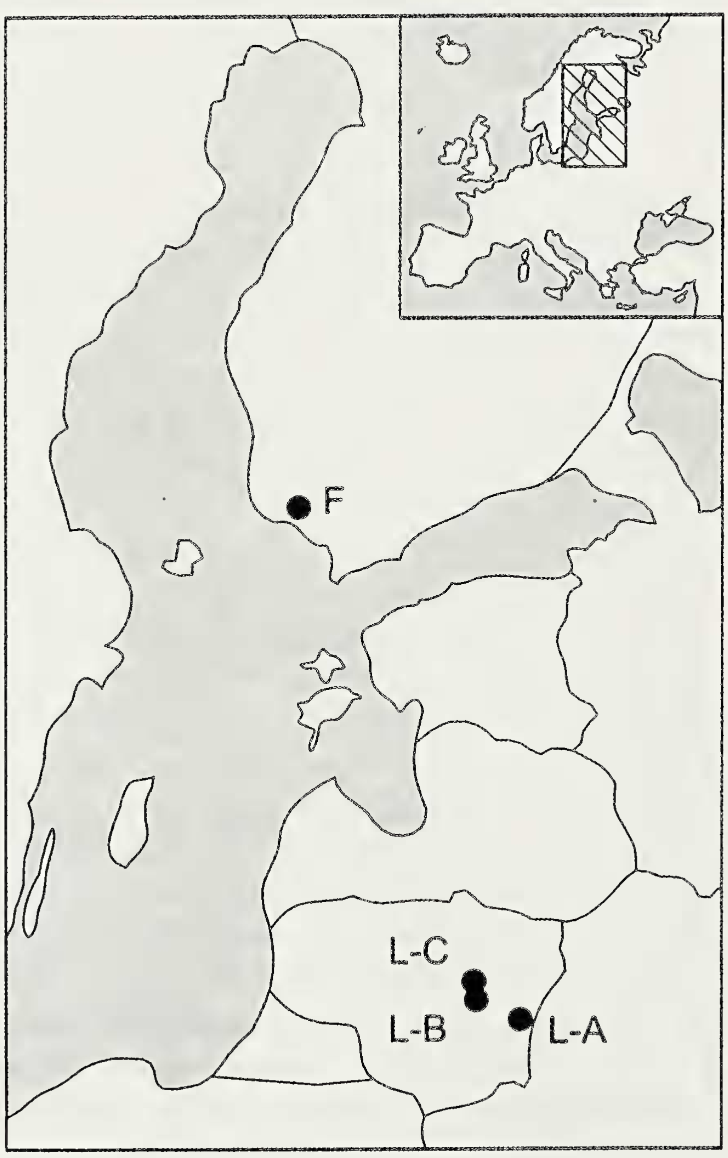

Figure 1.—Study sites in northern Europe: L-A = Balosa, L-B = Kertusas, and L-C = Laukenai (Lithuania), F = Kareva (Finland).

found during the investigation are newly reported for Lithuanian. These are: *Robertus lyrifer* Holm 1939, *Theridium mystaceum* L. Koch 1870 (both Theridiidae), *Diplocephalus dentatus* Tullgren 1955 (Linyphiidae), *Acantholycosa lignaria* (Clerck 1757) (Lycosidae) and *Xysticus lineatus* (Westring 1851) (Thomisidae). The list of species and numbers of individuals found in the peat bogs investigated in Lithuania are given in the Table 4.

Yearly turnover.—The turnover of species shows various trends when the whole data set is analyzed (Table 1). More species appeared from L-B and L-C, and disappeared in F. A situation close to equilibrium was recorded from L-A. Up to 52.7% of the species found during two years at the same place were only residents for a single year. The high proportion of species occurring in a single year from L-C (66.2%) was probably due to the relocation of the traps, where besides temporal turnover, there was also spatial turnover (Russell 1999). The case of L-A showed that low rates of turnover can be observed at the same place (Tn = 0.1), while the internal changes between the abundance groups remained well expressed (Table 2). On the other hand, the case of L-B showed that high rates of the turnover could also exist at the same place (Tn = 0.36).

The highest turnover rates were found in the group of species with three or fewer specimens. In the case of L-B, the high turnover

Table 2.—Turnover index (Tn) and percent similarity coefficient (PSc) in various dominance groups of peat bog spider communities in Lithuania and Finland. Localities as in Table 1. Asterisk (*) indicates the groups of species where no turnover occurred.

	Turnover index (Tn)				Percent similarity (PSc)			
	L-A	L-B	L-C	F	L-A	L-B	L-C	F
Whole set of species	0.1	0.36	0.49	0.3	67.5	62.3	49.7	59.5
Species with >3 individuals	0.09	0.1	0.25	0.09	68.1	63.0	50.4	59.7
Species with <3 individuals	0.36	0.79	0.81	0.65	56.0	32.9	11.9	45.4
Species with >1% of dominance	*	*	0.15	*	69.2	62.0	54.1	61.5
10 most abundant species	*	*	0.17	*	69.2	62.3	49.7	61.2

rate (Tn = 0.79) in this group of species influenced the high turnover rate of the entire data set (Tn = 0.36). The turnover rate for the rest of the community (> 3 individuals) was similar in all communities where no traps were relocated (Tn = 0.09–0.1). No turnover was found in the group of species representing more as 1% of the individuals, if the traps were not moved. Thus, the changes in this group of species were only due to increasing or decreasing abundance of species permanently occurring in the community.

Differences in abundance.—Other differences appearing in the communities between years are due to the changing abundance of species. This is the main cause of the observed differences in the groups of higher dominance in which no turnover occurred. It was clearly seen that the highest changes resulting in the lowest similarity values (PSc) in all selected groups were registered in peat bog L-C, where the traps were moved the following year (Table 2). The smallest changes (PSc = 67.5) were recorded in peat bog L-A, where moderate variation in the abundance in the most abundant species was observed. The higher differences in abundance of some dominate species, e.g., *Pardosa sphagnicola* (Dahl 1908), *Scotina palliardi* (L. Koch 1881), were found in peat bog L-B, and contributed to the lower similarity (PSc = 62.3) in this peat bog. The situation in Finnish peat bogs (PSc = 59.5) was similar to that observed from L-B. Higher differences as compared to the Lithuanian material could be caused by the additional year between samples.

Additionally we looked for the most stable group of species occurring at the same dominance level during both years. We found that there was a stable set of species (15–18) reaching more than 1% of dominance in one of the years. Only a few (2–3) species left this group and became less abundant in one of the years. In peat bog L-B there was only one such species. It is important to notice that no turnover was found in this dominance group if the traps remained in the same place.

A number of species remained abundant in all communities during both years of the study (Table 3), despite the changed sites in peat bog (L-C) or the geographical location of the site (cf. also Koponen et al. 2001). These spe-

Table 3.—Relative abundance (%) of the most abundant spider species consistently occurring in peat bogs in Lithuania and Finland. Localities as in Table 1.

	L-A99	L-A00	L-B99	L-B00	L-C99	L-C00	F-64	F-66
Pirata uliginosus	5.88	9.84	6.66	3.86	14.82	27.93	39.93	23.18
Trochosa spinipalpis	4.44	12.50	4.41	7.83	2.35	3.40	3.37	4.29
Lepthyphantes angulatus	4.96	3.06	2.08	1.98	0.87	0.82	2.61	1.03
Pardosa sphagnicola	9.15	9.04	27.96	1.54	23.10	1.88	3.02	2.15
Scotina palliardi	0.52	5.19	3.16	17.42	14.30	10.92	0.14	0.52
Centromerus arcanus	2.22	1.20	2.41	1.43	1.22	1.17	0.14	
Aulonia albimana	47.06	27.79	23.88	32.75	25.72	15.26		
Hygrolycosa rubrofasciata	5.09	9.44	3.16	1.76	0.17	2.58		

Table 4.—Species and numbers of spiders in peat bog communities studied in Lithuania in 1999 and 2000. Localities as in Table 1.

Localities	L-A99	L-A00	L-B99	L-B00	L-C99	L-C00
Crustulina guttata (Wider)						1
Dipoena prona (Menge)		1		2		
Euryopis flavomaculata (C. L. Koch)		1				2
Robertus arundineti (O.P.-Cambr.)						2
Robertus lividus (Blkw.)			1	2		
Robertus lyrifer Holm				1		
Theonoe minutissima (O.P.-Cambr.)	1	7	1	9		4
Theridion mystaceum L. Koch			1			
Agyneta cauta (O.P.-Cambr.)	3	23	142	46	1	95
Agyneta conigera (O.P.-Cambr.)				6		1
Agyneta decora (O.P.-Cambr.)						1
Bathyphantes gracilis (Blkw.)					3	
Centromerus aequalis (Westring)	1			1		
Centromerus arcanus (O.P.-Cambr.)	17	9	29	13	14	10
Centromerus levitarsis (Simon)	3	2			13	
Centromerus sylvaticus (Blkw.)			4	1	4	
Ceratinella brevis (Wider)			2	3	1	2
Cnephalocotes obscurus (Blkw.)	1	1	3	4	15	
Diplocephalus dentatus Tullgren						1
Dismodicus elevatus (C. L. Koch)				1		
Gonatium rubens (Blkw.)	3	7	3	1		
Gongylidiellum murcidum Simon	1					
Lepthyphantes angulatus (O.P.-Cambr.)	38	23	25	18	10	7
Lepthyphantes cristatus (Menge)	1		6	2		3
Lepthyphantes mengei Kulcz.		4		1	3	
Linyphia trianguaris (Clerck)	1					
Lophomma punctatum (Blkw.)				1		
Macrargus carpenteri (O.P.-Cambr.)				2		2
Maro minutus O.P.-Cambr.				7	2	23
Meioneta affinis (Kulcz.)						2
Meioneta mossica Schikora					1	
Micrargus apertus (O.P.-Cambr.)			4	3	1	
Microneta viaria (Blkw.)				2		
Neriene radiata (Walck.)	1	1				
Pocadicnemis pumila (Blkw.)	1	10	22	41	1	13
Savignia frontata Blkw.						1
Sintula corniger (Blkw.)			5	2	5	2
Stemonyphantes lineatus (Linnaeus)			1		2	
Tallusia experta (O.P.-Cambr.)	9	6	2	1	13	
Tapinocyba insecta (L. Koch)				1		
Tapinocyba pallens (O.P.-Cambr.)					1	
Taranucnus setosus (O.P.-Cambr.)	1	1		1	2	
Walckenaeria alticeps (Denis)	2	10	15	24		6
Walckenaeria atrotibialis O.P.-Cambr.	4	6	11	7	1	6

Table 4.—Continued.

Localities	L-A99	L-A00	L-B99	L-B00	L-C99	L-C00
Walckenaeria cuspidata Blkw.	1			1	1	
Walckenaeria karpinskii (O.P.-Cambr.)		1				
Walckenaeria nodosa O.P.-Cambr.				1	9	
Walckenaeria nudipalpis (Westring)	2	1	2	3		1
Pachygnatha clercki Sundevall					1	1
Pachygnatha degeeri Sundevall	1		1	2	7	1
Pachygnatha listeri Sundevall						2
Cercidia prominens (Westring)	4		4			2
Hyposinga sanguinea (C. L. Koch)						1
Acantholycosa lignaria (Clerck)			1			
Alopecosa pulverulenta (Clerck)	53	12				
Arctosa alpigena (Doleschall)			5		15	2
Aulonia albimana (Walck.)	360	209	287	297	295	130
Hygrolycosa rubrofasciata (Ohlert)	39	71	38	16	2	22
Pardosa lugubris (Walck.)				1		
Pardosa prativaga (L. Koch)	4	7		1		3
Pardosa pullata (Clerck)	2	3		1	11	66
Pardosa sphagnicola (Dahl)	70	68	264	14	265	16
Pirata hygrophilus Thorell			3	5		
Pirata insularis Emerton			2	5		
Pirata piraticus (Clerck)			1			
Pirata ulginosus (Thorell)	45	74	80	35	170	238
Trochosa ruricola (De Geer)	2	2				
Trochosa spinipalpis (F.O.P.-Cambr.)	34	94	53	71	27	29
Dolomedes fimbriatus (Clerck)	2			1		
Antistea elegans (Blkw.)	3	3	3	1	32	
Hahnia pusilla C. L. Koch	1	2	4	7		13
Cicurina cicur (Fabricius)			2			
Agroeca brunnea (Blkw.)	1	4				
Agroeca dentigera Kulcz.	7	11		1	3	7
Aroeca proxima (O.P.-Cambr.)	1	2		1		2
Phrurolithus festivus (C. L. Koch)		4	2	3		
Phrurolithus minimus C. L. Koch	2					
Scotina palliardi (L. Koch)	4	39	38	158	164	93
Clubiona diversa O.P.-Cambr.					1	
Drassodes pubescens (Thorell)	1		1			
Drassyllus lutetianus (L. Koch)	4	2	2	2		2
Drassyllus pusillus (C. L. Koch)	5	3	64	11	41	10
Gnaphosa microps Holm	5	9	46	33	2	
Gnaphosa nigerrima L. Koch	4	2			2	
Haplodrassus moderatus (Kulcz.)		3	1			
Haplodrassus signifer (C. L. Koch)	3	1	2	6	4	4
Haplodrassus silvestris (Blkw.)	1					
Haplodrassus soerenseni (Strand)						1
Micaria pulicaria (Sundevall)				3		

Table 4.—Continued.

Localities	L-A99	L-A00	L-B99	L-B00	L-C99	L-C00
Zelotes clivicola (L. Koch)				1		
Zelotes latreillei (Simon)	2	1	3		1	1
Zelotes longipes (L. Koch)						1
Zelotes subterraneus (C. L. Koch)	1					
Zora silvestris Kulcz.		1	9	9	1	1
Zora spinimana (Sundevall)	7	4	1			
Xysticus cristatus (Clerck)	1	1		1		1
Xysticus lineatus (Westring)						4
Xysticus ulmi (Hann)		1				
Euophrys frontalis (Walck.)				1		
Euophrys westringi (Simon)	1	3		2		3
Evarcha arcuata (Clerck)	2	1				
Evarcha falcata (Clerck)				5		
Evarcha laetabunda (C. L. Koch)						2
Heliophanus dubius C. L. Koch				1		
Neon reticulatus (Blkw.)	2	1	5	4		8
Neon valentulus Falconer						1
Talavera petrensis C. L. Koch			1			
Spider totals	765	752	1202	907	1147	852
Species totals each year	52	48	47	62	40	51
Species totals in two years		60		74		68

cies are the most stable components of epigeic peat bog spider communities in the entire investigated region. Absence or lower than typical abundance of such species can probably indicate disturbance of the peat bog habitat. *Pirata uliginosus* (Thorell 1856), *Centromerus arcanus* (O.P.-Cambridge 1873) and *Lepthyphantes angulatus* (O.P.-Cambridge 1881) showed the lowest differences in abundance between the two years. On the other hand, some large differences in the abundance of some typical peat bog species were found between the studied years. *Pardosa sphagnicola* showed differences in one locality (L-B) similar to those observed in the case of the changed site (L-C), but the dominance of this species always exceeded 1%. Marked differences in abundance have been recorded for *Aulonia albimana* (Walckenaer 1805) occurring only in Lithuania, but this species was always dominant in the communities investigated (Table 3). *Trochosa spinipalpis* (F.O.P.-Cambridge 1859) from L-A and *Scotina palliardi* from L-A and L-B showed much larger differences in abundance at the same locality as compared to the differences found when the traps were moved (Table 3). Such fluctuations in the abundance of even typical peat bog species could lead to erroneous interpretations of the data about respective species living in peat bogs and should be considered if studies are restricted to one year.

The data show that most of the species found in both years were mainly hygrophilous or typical peat bog species. Only a few species that are common in other habitats were often abundant (> 1%) in any of the studied peat bogs during both years: *Alopecosa pulverulenta* (Clerck 1757) at L-A and F, *Agyneta cauta* (O.P.-Cambridge 1902) at L-B and F, *Pardosa prativaga* (L. Koch 1870) at L-A, *Pardosa pullata* (Clerck 1757) in F, *Drassyllus pusillus* (C. L. Koch 1833) and *Walckenaeria alticeps* (Denis 1952) at L-B.

Effect of repositioning.—The data obtained from peat bog L-C, where the traps were moved in the second year, showed considerable differences compared to the other communities. This repositioning resulted in a higher turnover and a lower similarity in all abundance groups in comparison to the other peat bogs (Table 2). The turnover (five species, $Tn = 0.15$) occurred even in the species with high abundance (> 1%), which was not the case in the other peat bogs. The relocation of traps did not markedly affect the total number of species collected. The number remained lower (68 species) than L-B (74). The lowest number of permanently found species, recorded as three or fewer specimens (4 species), was recorded in this peat bog, while 15 and 14 such species were found at L-A and F respectively. The highest difference in abundant species was found at L-C as well. From species with more than 3 individuals, 28% occurred during a single year of study at L-C, while only 11.1% and 8.3% occurred for a single year at L-A and L-B, respectively. Not all the differences found at L-C could be explained by temporal turnover or by the changes in abundance observed in other peat bogs. As it was already mentioned, the spatial turnover was an additional case here and contributed to the higher differences (Russell 1999). Thus, an aggregated distribution of spiders and heterogeneity of their communities in peat bogs could be supposed despite similar vegetation.

Data from Finland.—Despite slightly different methods, geographical location and time of research, the Finland data showed similar trends to communities studied in Lithuania. Geographically defined differences between peat bog spider communities have been analyzed (Koponen et al. 2001). Most of the abundant (> 0.5%) species registered in Finland, with exception of those known only for Finland, were also abundant in Lithuanian peat bogs during one or both years (Table 3). Lower similarity between the samples could be the result of the one year interval between collections in Finland. The turnover (Tn = 0.3) was the same as that observed in Lithuania (Table 2).

CONCLUSIONS

Peat bogs are stable and slowly changing habitats if natural conditions are preserved (Masing 1984; Succow 2000). However, in the case of spider faunas, studied by the means of pitfall traps, high variation in species composition and abundance occurred between years in peat bogs. Even some typical peat bog species show considerable differences in their abundance. Hence, the occurrence of large fluctuations should be taken into account in inventories of fauna and in studies using indicator species in peat bogs. It could be suggested that the 15 most abundant species be used to get the main representative set of species if study is restricted to a single year. The species in this set do not undergo turnover and they remain abundant during two consecutive years in peat bogs investigated in Lithuania. This set, consisting mainly of hygrophilous or typical peat bog species, can be easily defined and used as a diagnostic tool for the natural state of peat bog habitats. We assume that the growing number and permanent abundant occurrence of eurytopic species or species especially typical of other habitats may indicate changes in living conditions in a peat bog.

The part of the species in the groups showing the highest turnover may be species entering communities passively by ballooning. These species (sometimes in high numbers) land in inappropriate habitats and live there only temporarily, causing turnover. Marked differences in spider communities were revealed if traps were relocated in the same peat bog. Communitues were also influenced by additional spatial turnover. The results clearly follow statement of Russell (1999), that "the greater the separation in time or space, the greater the difference in species composition". This statement is supported also by data from Finland, showing higher differences between samples separated by a single year in comparison to the samples from two consecutive years in Lithuania.

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LITERATURE CITED

Coddington, J.A., L.H. Young & F.A. Coyle. 1996. Estimating spider richness in a Southern Appalachian cove hardwood forest. Journal of Arachnology 24:111–128.

Duelli, P., M. Stader & E. Katz. 1990. Minimalprogramme für die Erhebung und Aufbereitung zooökologischen Daten als Fachbeiträge zur Plannungen am Beispiel ausgewählter Arthropodengruppen. Schriftenreihe für Landschaftspflege und Naturschutz 32:21–222.

Duelli, P. 1997. Biodiversity evaluation in agricultural landscapes: An approach at two different scales. Agriculture, Ecosystems & Environment 62:81–91.

Koponen, S. 1979. Differences of spider fauna in natural and man-made habitats in a raised bog. The National Swedish Environment Protection Board, Report PM II 51:104–108.

Koponen, S. 1994. Ground-living spiders, opilionids, and pseudoscorpions of peatlands in Quebec. Memoirs of the Entomological Society of Canada 169:41–60.

Koponen, S., V. Relys & D. Dapkus. 2001. Changes in structure of ground-living spider (Araneae) communities on peatbogs along a transect from Lithuania to Lapland. Norwegian Journal of Entomology 48:167–174.

Kuprijanowitz, J., I. Hajdamowicz, A. Stankiewicz & W. Starega. 1998. Spiders of some raised peat bogs in Poland. Pp. 267—272. *In* Proceedings of the 17th European Colloquium Of Arachnology, Edinburgh, 1997. (P. A. Selden, ed.). British Arachnological Society, Bucks.

MacArthur, R.H. & E.O. Wilson. 1967. The Theory of Island Biogeography. Princeton University Press, Princeton 203 pp.

Masing, V. 1984. Estonian Bogs: Plant Cover, Succession and Classification. Pp. 119–148. *In* European Mires. (P.D. Moore, ed.) Academic Press. London.

Norris, K.C. 1999. Quantifying change through time in spider assemblages: sampling methods, indices and sources of error. Journal of Insect Conservation 3:309–325.

Platen, R. 1989. Veränderungen der Spinnenfauna (Arachnida: Araneida) in Moorschutzgebieten von Berlin (West). Schriftenreihe für Landschaftspflege und Naturschutz 29:296–301.

Platnick, N.I. 1997. Advances in spider taxonomy 1992–1995. New York Entomological Society & the American Museum of Natural History New York. 976 pp.

Relys, V. & D. Dapkus. 2002. Similarities between epigeic spider communities in a peatbog and surrounding pine forest: a study from southern Lithuania. Pp. 207–214. *In* European Arachnology 2000 (S. Toft & N. Scharff eds.) Aarhus University Press. Aarhus. (In press).

Riecken, U. 1999. Effects of short-term sampling on ecological characterization and evaluation of epigeic spider communities and their habitats for site asessment studies. Journal of Arachnology 27:189–195.

Riecken, U. 2000. Raumeinbindung und Habitatnutzung epigäischer Arthropoden unter den Bedingungen der Kulturlandschaft. Schriftenreihe für Landschaftspflege und Naturschutz 61. 196pp.

Russell, G.J. 1999. Turnover: biological change at all scales of space and time. *In* Biodiversity Dynamics: Turnover of Populations, Species and Higer Taxa (M.L. Mckinney ed.). Columbia: Columbia University Press.

Russell, G.J., J.M. Diamond, S.L. Pimm & T.M. Reed. 1995. A century of turnover: community dynamics at three timescales. Journal of Animal Ecology 64:628–641.

Schikora, H.B. 1994. Changes in the terrestrial spider fauna (Arachnida: Araneae) of a North German raised bog disturbed by human influence. 1964–1965 and 1986–1987: A comparison. Memoirs of the Entomological Society of Canada 169:61–71.

Schikora, H. B. 1997. Wachsende Regenmoorflächen im Zehlaubruch (Kaliningrad-Region): Extremlebensraum für epigäische Spinnen (Arachnida: Araneae)? Verhandlungen der Gesellschaft für Ökologie 27:447–452.

Succow, M. 2000. Landschaftsökologische Moorkunde. Fischer, Stuttgart. 364 pp.

Wolda, H. 1981. Similarity indices, sample size and diversity. Oecologia 50:296–302.

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